

## WHAT IS CLAIMED IS:

1. A method for the production of a multiple phase composite material, wherein the composite material comprises a major phase component and at least one minor phase component arranged in a desired predefined morphological structure in which said major phase component and said at least one minor phase component have predefined size and shape characteristics, the method comprising the steps of:

supplying said major phase component to a chaotic mixer in a substantially controlled manner ;

10       supplying said at least one minor phase component to said chaotic mixer in a substantially controlled manner;

chaotically mixing said major phase component with said at least one minor phase component within said chaotic mixer according to controlled mixing parameters to controllably and progressively develop

15       the morphologies of said major phase component and said at least one minor phase component such that said major phase component and said at least one minor phase component form an in-situ structured arrangement of predetermined and controllable morphology within said chaotic mixer and wherein at least one of the group consisting of said

20       major phase component and said at least one minor phase component is in a substantially liquid state during mixing; and

controllably forming said in-situ structured arrangement into a substantially solid multiple phase construction having said desired predefined morphological structure wherein said major phase

25       component and said at least one minor phase component are present in the form of phase structures having size and shape characteristics corresponding substantially to said predefined size and shape characteristics.

2. The method as recited in claim 1, wherein said major phase component comprises a polymeric material.

3. The method as recited in claim 2, wherein said major phase component is in a substantially fluid state during the chaotically mixing step.

4. The method as recited in claim 2, wherein said at least one minor phase component comprises a polymeric material.

5. The method as recited in claim 4, wherein said at least one minor phase component is in a substantially fluid state during the chaotically mixing step.

6. The method as recited in claim 1, wherein said major phase component comprises a non-polymeric viscous material.

7. The method as recited in claim 1, wherein said at least one minor phase component comprises a non-polymeric viscous material.

8. The method as recited in claim 1, wherein the chaotically mixing step is carried out as substantially two dimensional chaotic mixing.

9. The method as recited in claim 1, wherein the chaotically mixing step is carried out as substantially three dimensional chaotic mixing.

10. The method as recited in claim 1, wherein the chaotically mixing step comprises a plurality of substantially discrete controllable mixing stages of differing functionality to produce predetermined staged morphology changes within the group consisting of said major phase component and said at least one minor phase component.

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11. The method as recited in claim 10, wherein the chaotically mixing step includes selectively varying the shear rate in the chaotic mixer.

12. The method as recited in claim 10, wherein the chaotically mixing step includes utilizing a selective combination of two dimensional chaotic mixing and three dimensional chaotic mixing.

13. The method as recited in claim 10, wherein the chaotically mixing step includes reversing the direction of mixing.

14. The method as recited in claim 1, wherein the controllably forming step includes delivering said in-situ structured arrangement to a die for forming and wherein the morphology of the in-situ structured arrangement delivered to the die is substantially controlled prior to delivery to the die, and such that the die is selected to cause predetermined and controllable further morphological change.

15. The method as recited in claim 1, wherein said predefined morphological structure comprises a plurality of substantially discrete alternating layers of said major phase component and said at least one minor phase component in substantially aligned orientation.

16. The method as recited in claim 15, wherein the controllably forming step includes delivering said in-situ structured arrangement to a die to further align and compress said substantially discrete alternating layers.

17. The method as recited in claim 1, wherein said at least one minor phase component comprises a substantially solid phase material which remains in a substantially unmelted state within said chaotic mixer

and said major phase component comprises a polymeric material which  
5 is in a substantially liquid state within said chaotic mixer.

18. The method as recited in claim 1, wherein said major  
phase component comprises a substantially solid phase material which  
remains in a substantially unmelted state within said chaotic mixer and  
said at least one minor phase component comprises a polymeric  
5 material which is in a substantially liquid state within said chaotic mixer.

19. The method as recited in claim 1, wherein said predefined  
morphological structure comprises a plurality of substantially discrete  
alternating layers of said major phase component and said at least one  
minor phase component in substantially aligned orientation and wherein  
5 the number of said layers is substantially controllable during the  
chaotically mixing step such that increased chaotic mixing yields a larger  
number of progressively thinning layers whereby the number and  
thickness of said layers is substantially controllable by controlling the  
chaotically mixing step.

21. The method as recited in claim 20, wherein said chaotically  
mixing step is terminated at a predetermined level such that said layers  
have a predetermined thickness.

22. The method as recited in claim 1, wherein said multiple  
phase composite material includes two or more minor phase  
components.

23. The method as recited in claim 1, wherein said multiple  
phase composite material includes three or more polymeric constituents.

24. The method as recited in claim 1, wherein said major phase component and said at least one minor phase component within said structured arrangement are polymeric materials and wherein the interfacial tension between said polymeric materials is less than about  
5 10mN/m.

25. The method as recited in claim 1, wherein said major phase component and said at least one minor phase component within said structured arrangement are polymeric materials and wherein the interfacial tension between said polymeric materials is not greater than  
5 about 4mN/m.

26. The method as recited in claim 1, wherein said major phase component and said at least one minor phase component within said structured arrangement are polymeric materials and wherein the interfacial tension between said polymeric materials is not greater than  
5 about 2 mN/m.

27. The method as recited in claim 26, wherein at least one of the group consisting of said major phase component and said at least one minor phase component includes an additive to reduce interfacial tension.

28. The method as recited in claim 1, wherein said predefined morphological structure comprises a plurality of substantially discrete alternating layers of said major phase component and said at least one minor phase component, wherein at least a portion of said layers include  
5 holes of controllable size extending across said layers, the number of said layers being substantially controllable during the chaotically mixing step such that increased chaotic mixing yields a larger number of progressively thinning layers whereby the number and thickness of said layers is substantially controllable by controlling the chaotically mixing

10 step and the number and size of said holes being substantially controllable during the chaotically mixing step such that increased chaotic mixing yields a larger number of holes of increasing size.

29. A method for the production of a multiple phase composite material, wherein the composite material comprises a major phase component and at least one minor phase component arranged in a desired predefined morphological structure in which said major phase component and said at least one minor phase component have predefined size and shape characteristics, the method comprising the steps of:

supplying said major phase component to a chaotic mixer in a substantially continuous manner;

10 supplying said at least one minor phase component to said chaotic mixer in a substantially continuous manner;

chaotically mixing said major phase component with said at least one minor phase component within said chaotic mixer according to controlled mixing parameters such that said major phase component and said at least one minor phase component form an in-situ structured arrangement of predetermined and controllable morphology within said chaotic mixer and wherein at least one of the group consisting of said major phase component and said at least one minor phase component is in a substantially liquid state during mixing;

15 continuously discharging said in-situ structured arrangement from the chaotic mixer in the form of a structured extrudate of controllable morphological character;

20 controlling the chaotic mixing step to controllably and progressively develop the morphologies of said major phase component and said at least one minor phase component within said structured extrudate; and

25 controllably forming said structured extrudate into a substantially solid construction having said predefined morphological structure.

30. The method as recited in claim 29, wherein said major phase component comprises a polymeric material.

31. The method as recited in claim 30, wherein said major phase component is in a substantially liquid state during the chaotically mixing step.

32. The method as recited in claim 30, wherein said at least one minor phase component comprises a polymeric material.

33. The method as recited in claim 32, wherein said at least one minor phase component is in a substantially liquid state during the chaotically mixing step.

34. The method as recited in claim 29, wherein said major phase component comprises a non-polymeric viscous material.

35. The method as recited in claim 29, wherein said at least one minor phase component comprises a non-polymeric viscous material.

36. The method as recited in claim 29, wherein the chaotically mixing step is carried out as substantially two dimensional chaotic mixing.

37. The method as recited in claim 29, wherein the chaotically mixing step is carried out as substantially three dimensional chaotic mixing.

38. The method as recited in claim 29, wherein the chaotically mixing step comprises a plurality of substantially discrete controllable mixing stages of differing functionality to produce predetermined staged

5 morphology changes within the group consisting of said major phase component and said at least one minor phase component.

39. The method as recited in claim 38, wherein the controlling step includes selectively varying the shear rate in the chaotic mixer during the chaotically mixing step.

40. The method as recited in claim 38, wherein the controlling step includes utilizing a selective combination of two dimensional chaotic mixing and three dimensional chaotic mixing during the chaotically mixing step.

41. The method as recited in claim 38, wherein the controlling step includes reversing the direction of mixing during the chaotically mixing step.

42. The method as recited in claim 29, wherein the controllably forming step includes delivering said structured extrudate to a die for forming.

43. The method as recited in claim 29, wherein said predefined morphological structure comprises a plurality of substantially discrete alternating layers of said major phase component and said at least one minor phase component in substantially aligned orientation.

44. The method as recited in claim 43, wherein the controllably forming step includes delivering said structured extrudate to a die to further align and compress said substantially discrete alternating layers.

45. The method as recited in claim 29, wherein said at least one minor phase component comprises a substantially solid phase

material which remains in a substantially unmelted state within said chaotic mixer and said major phase component comprises a polymeric material which is in a substantially liquid state within said chaotic mixer.

46. The method as recited in claim 29, wherein said major phase component comprises a substantially solid phase material which remains in a substantially unmelted state within said chaotic mixer and said at least one minor phase component comprises a polymeric material which is in a substantially liquid state within said chaotic mixer.

47. The method as recited in claim 29, wherein said predefined morphological structure comprises a plurality of substantially discrete alternating layers of said major phase component and said at least one minor phase component in substantially aligned orientation and wherein the number of said layers is substantially controllable by controlling the chaotically mixing step such that increased chaotic mixing yields a larger number of progressively thinning layers whereby the number and thickness of said layers is substantially controllable by controlling the chaotically mixing step.

48. The method as recited in claim 47, wherein said chaotically mixing step is terminated at a predetermined level such that said layers have a predetermined thickness.

49. The method as recited in claim 29, wherein said multiple phase composite material includes two or more minor phase components.

50. The method as recited in claim 29, wherein said multiple phase composite material includes three or more polymeric constituents.

51. The method as recited in claim 29, wherein said major phase component and said at least one minor phase component within said structured arrangement are polymeric materials and wherein the interfacial tension between said polymeric materials is less than about  
5 10mN/m.

52. The method as recited in claim 29, wherein said major phase component and said at least one minor phase component within said structured arrangement are polymeric materials and wherein the interfacial tension between said polymeric materials is not greater than  
5 about 4mN/m.

53. The method as recited in claim 29, wherein said major phase component and said at least one minor phase component within said structured arrangement are polymeric materials and wherein the interfacial tension between said polymeric materials is not greater than  
5 about 2 mN/m.

54. The method as recited in claim 29, wherein said predefined morphological structure comprises a plurality of substantially discrete alternating layers of said major phase component and said at least one minor phase component, wherein at least a portion of said  
5 layers include holes of controllable size extending across said layers, the number of said layers being substantially controllable during the chaotically mixing step such that increased chaotic mixing yields a larger number of progressively thinning layers whereby the number and thickness of said layers is substantially controllable by controlling the  
10 chaotically mixing step and the number and size of said holes being substantially controllable during the chaotically mixing step such that increased chaotic mixing yields a larger number of holes of increasing size.

55. A method for the production of a multiple phase composite material, wherein the composite material comprises a major phase component and at least one minor phase component arranged in a desired predefined morphological structure in which said major phase component and said at least one minor phase component have predefined size and shape characteristics, the method comprising the steps of:

supplying said major phase component to a chaotic mixer in a substantially continuous manner at a controlled flow rate;

10 supplying said at least one minor phase component to said chaotic mixer in a substantially continuous manner at a controlled flow rate;

chaotically mixing said major phase component with said at least one minor phase component within said chaotic mixer while the

15 supplying steps are ongoing such that said major phase component and said at least one minor phase component are arranged in an in-situ structured arrangement having a structural morphology developed substantially progressively within said chaotic mixer according to a pre-established controllable evolutionary process, wherein said structural morphology is selected from the group consisting of substantially continuous multi-layered films, multi-layered films wherein at least a portion of the layers include holes of controllable size, interpenetrating blends, platelets, fibers, droplet dispersions and combinations thereof;

20 controlling the chaotically mixing step and the supplying steps

25 independently to yield predefined size and shape characteristics of said major phase component and said at least one minor phase component within said in situ structured arrangement;

discharging said in-situ structured arrangement from said chaotic mixer in the form of a structured extrudate; and

30 controllably forming said structured extrudate into a substantially solid construction having said predefined morphological structure.

56. The method as recited in claim 55, wherein said structured extrudate is discharged to a die inlet for ~~subsequent~~ formation.

57. The method as recited in claim 55, wherein said major phase component comprises a polymeric material.

58. The method as recited in claim 57, wherein said major phase component is in a substantially liquid state during the chaotically mixing step.

59. The method as recited in claim 55, wherein said at least one minor phase component comprises a polymeric material.

60. The method as recited in claim 59, wherein said at least one minor phase component is in a substantially liquid state during the chaotically mixing step.

61. The method as recited in claim 55, wherein said major phase component comprises a non-polymeric viscous material.

62. The method as recited in claim 55, wherein said at least one minor phase component comprises a non-polymeric viscous material.

63. The method as recited in claim 55, wherein the chaotically mixing step is carried out as substantially two dimensional chaotic mixing.

64. The method as recited in claim 55, wherein the chaotically mixing step is carried out as substantially three dimensional chaotic mixing.

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65. The method as recited in claim 55, wherein the chaotically mixing step comprises a plurality of substantially discrete controllable mixing stages of differing functionality to produce predetermined staged morphology changes within the group consisting of said major phase component and said at least one minor phase component.

66. The method as recited in claim 65, wherein the controlling step includes selectively varying the shear rate in the chaotic mixer at different stages during the chaotically mixing step.

67. The method as recited in claim 65, wherein the controlling step includes utilizing a selective combination of two dimensional chaotic mixing and three dimensional chaotic mixing during the chaotically mixing step.

68. The method as recited in claim 65, wherein the controlling step includes reversing the direction of mixing during the chaotically mixing step whereby structural morphology development is at least partially reversed.

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69. The method as recited in claim 55, wherein the controllably forming step includes delivering said structured extrudate to a die for forming treatment.

70. The method as recited in claim 55, wherein said at least one minor phase component comprises a substantially solid phase material which remains in a substantially unmelted state within said chaotic mixer and said major phase component comprises a polymeric material which is in a substantially liquid state within said chaotic mixer.

71. The method as recited in claim 55, wherein said major phase component comprises a substantially solid phase material which remains in a substantially unmelted state within said chaotic mixer and said at least one minor phase component comprises a polymeric material which is in a substantially liquid state within said chaotic mixer.

5           72. The method as recited in claim 55, wherein said multiple phase composite material includes two or more minor phase components,

73. The method as recited in claim 55, wherein said multiple phase composite material includes three or more polymeric constituents.

74. The method as recited in claim 55, wherein at least one of the group consisting of said major phase component and said at least one minor phase component includes an interfacial tension reducing additive.

75. A method for the production of a multiple phase composite construction, wherein the composite construction comprises a major phase component and at least one minor phase component arranged in a desired predefined morphological structure comprising a plurality of 5 substantially continuous layers of predefined size, the method comprising the steps of:

supplying said major phase component to a chaotic mixer in a substantially controlled manner;

10       supplying said at least one minor phase component to said chaotic mixer in a substantially controlled manner;

chaotically mixing said major phase component with said at least one minor phase component within said chaotic mixer such that said major phase component and said at least one minor phase component

assume an in-situ structured arrangement developed progressively  
15 within said chaotic mixer according to a pre-established controllable evolutionary and at least partially reversible process, such that at a preliminary stage of said chaotic mixing, said in-situ structured arrangement comprises a plurality of substantially continuous layers of said major phase and said at least one minor phase disposed in  
20 substantially layered relation to one another and wherein upon further chaotic mixing said substantially continuous layers increase in number and undergo progressive thinning to a vanishingly thin level approaching the molecular thickness of the material forming said layers and thereafter undergo subsequent morphological transition away from  
25 substantially continuous layers and towards structures selected from the group consisting of layers with holes therein, platelets, interpenetrating blends, fibers, droplet dispersions and combinations thereof; and  
controlling the chaotic mixing step such that said in-situ structured  
30 arrangement comprises a plurality of extended substantially discrete layers of predetermined size and shape of said major phase component and said at least one minor phase component;  
discharging said in-situ structured arrangement from said chaotic mixer in the form of a structured extrudate; and  
35 controllably forming said structured extrudate into a substantially solid construction having said predefined morphological structure.

76. A multilayered composite construction formed according to the method as recited in claim 75, wherein said substantially continuous layers have an average thickness in the range of not greater than about 200 nanometers.

77. A multilayered composite construction formed according to the method as recited in claim 75, wherein said substantially continuous

layers have an average thickness in the range of not greater than about 100 nanometers.

78. A multilayered composite construction formed according to the method as recited in claim 75, wherein said substantially continuous layers have an average thickness in the range of not greater than about 50 nanometers.

79. A multilayered composite construction formed according to the method as recited in claim 75 comprising greater than about 6 layers.

80. A multilayered composite construction formed according to the method as recited in claim 75 comprising in the range of about 10 - 100 layers.

81. A multilayered construction formed according to the method as recited in claim 75 comprising in the range of about 100 - 1000 layers.

82. A multilayered construction formed according to the method as recited in claim 75 comprising in the range of about 1000 - 10,000 layers.

83. A multilayered construction formed according to the method as recited in claim 75 comprising in the range of about 100 to about 12,000 layers.

84. A multilayered construction formed according to the method as recited in claim 75 comprising about 100 to about 12,000 layers and wherein said layers have an average thickness in the range of not greater than about 200 nanometers.

85. The method as recited in claim 75, wherein said structured extrudate is conveyed to a die inlet for further alignment of said extended substantially discrete layers.

86. The method as recited in claim 75, wherein said major phase component comprises a polymeric material.

87. The method as recited in claim 86, wherein said major phase component is in a substantially liquid state during the chaotically mixing step.

88. The method as recited in claim 75, wherein said at least one minor phase component comprises a polymeric material.

89. The method as recited in claim 88, wherein said at least one minor phase component is in a substantially liquid state during the chaotically mixing step.

90. The method as recited in claim 75, wherein during the chaotically mixing step the viscosity of said at least one minor phase component divided by the viscosity of said major phase component is in the range of 0.5 to about 15.

91. The method as recited in claim 75, wherein said major phase component comprises a non-polymeric viscous material.

92. The method as recited in claim 75, wherein said at least one minor phase component comprises a non-polymeric viscous material.

93. The method as recited in claim 75, wherein the chaotically mixing step is carried out as substantially two dimensional chaotic mixing.

94. The method as recited in claim 75, wherein the chaotically mixing step is carried out as substantially three dimensional chaotic mixing.

95. The method as recited in claim 75, wherein the chaotically mixing step comprises a plurality of substantially discrete controllable mixing stages of differing functionality to produce predetermined staged morphology changes within the group consisting of said major phase component and said at least one minor phase component.

96. The method as recited in claim 95, wherein the controlling step includes selectively varying the shear rate in the chaotic mixer at different stages during the chaotically mixing step.

97. The method as recited in claim 95, wherein the controlling step includes utilizing a selective combination of two dimensional chaotic mixing and three dimensional chaotic mixing during the chaotically mixing step.

98. The method as recited in claim 95, wherein the controlling step includes reversing the direction of mixing during the chaotically mixing step whereby structural morphology development is at least partially reversed.

99. The method as recited in claim 75, wherein the controllably forming step includes delivering said structured extrudate to a die for forming treatment.

100. The method as recited in claim 75, wherein said at least one minor phase component comprises a substantially solid phase material which remains in a substantially unmelted state within said chaotic mixer and said major phase component comprises a polymeric material which is in a substantially liquid state within said chaotic mixer.

101. The method as recited in claim 75, wherein said major phase component comprises a substantially solid phase material which remains in a substantially unmelted state within said chaotic mixer and said at least one minor phase component comprises a polymeric material which is in a substantially liquid state within said chaotic mixer.

102. The method as recited in claim 75, wherein said multiple phase composite material includes two or more minor phase components.

103. The method as recited in claim 75, wherein said multiple phase composite material includes three or more polymeric constituents.

104. The method as recited in claim 75, wherein at least one of the group consisting of said major phase component and said at least one minor phase component includes an interfacial tension reducing additive.

105. The method as recited in claim 75, wherein said major phase component is electrically conductive and said at least one minor phase component is substantially electrically non-conductive.

106. The method as recited in claim 75, wherein said major phase component is substantially electrically non-conductive and said at least one minor phase component is electrically conductive.

107. A method for the manufacture of a multiple phase composite construction having a major phase component and at least one minor phase component arranged in a desired predefined morphological structure comprising a plurality of substantially discrete layers with holes of predetermined size extending through one or more of said substantially discrete layers, the method comprising the steps of:

5        supplying said major phase component to a chaotic mixer in a substantially controlled manner;

10      supplying said at least one minor phase component to said chaotic mixer in a substantially controlled manner;

15      chaotically mixing said major phase component with said at least one minor phase component within said chaotic mixer such that said major phase component and said at least one minor phase component form an in-situ structured arrangement of structured morphology

20      developed progressively within said chaotic mixer according to a pre-established controllable evolutionary process such that at a preliminary stage of said chaotic mixing, said in-situ structured arrangement comprises a plurality of substantially continuous layers of said major phase and said at least one minor phase disposed in substantially layered relation to one another and wherein upon further chaotic mixing said substantially continuous layers undergo progressive thinning and subsequent morphological transition towards layers with holes of increasing dimension; and

25      controlling the chaotically mixing step such that the chaotic mixing is terminated at a controlled stage following formation of said substantially continuous layers and during morphological transition away from said substantially continuous layers such that said major phase component and said at least one minor phase component comprise a plurality of substantially discrete extended layers of predetermined size

30      and shape of said major phase component and said at least one minor phase component wherein at least a portion of said substantially

discrete extended layers includes a plurality of holes of predetermined size;

35 discharging said in-situ structured arrangement from said chaotic mixer in the form of a structured extrudate; and

controllably forming said structured extrudate into a substantially solid construction having said predefined morphological structure.

108. A multilayered construction formed according to the method as recited in claim 107, wherein said substantially discrete extended layers have an average thickness in the range of not greater than about 200 nanometers.

109. A multilayered construction formed according to the method as recited in claim 107, wherein said substantially discrete extended layers have an average thickness in the range of not greater than about 100 nanometers.

110. A multilayered construction formed according to the method as recited in claim 107, wherein said substantially discrete extended layers have an average thickness in the range of not greater than about 50 nanometers.

111. A multilayered construction formed according to the method as recited in claim 107 comprising greater than about 7 layers.

112. A multilayered construction formed according to the method as recited in claim 107 comprising in the range of about 10 - 1000 layers.

113. A multilayered construction formed according to the method as recited in claim 107 comprising in the range of about 1000 - 10,000 layers.

114. A multilayered construction formed according to the method as recited in claim 107 comprising in the range of about 10 - 12,000 layers.

115. A multilayered construction formed according to the method as recited in claim 107 comprising about 100 to about 12,000 layers and wherein said layers have an average thickness in the range of not greater than about 200 nanometers.

116. The method as recited in claim 107, wherein said structured extrudate is transported to a die ~~inlet~~ for further alignment of said substantially discrete extended layers.

117. The method as recited in claim 107, wherein said major phase component comprises a polymeric material.

118. The method as recited in claim 117, wherein said major phase component is in a substantially liquid state during the chaotically mixing step.

119. The method as recited in claim 107, wherein said at least one minor phase component comprises a polymeric material.

120. The method as recited in claim 119, wherein said at least one minor phase component is in a substantially liquid state during the chaotically mixing step.

121. The method as recited in claim 107, wherein during the chaotically mixing step the viscosity of said at least one minor phase component divided by the viscosity of said major phase component is in the range of 0.5 to about 15.

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122. The method as recited in claim 107, wherein said major phase component comprises a non-polymeric viscous material.

123. The method as recited in claim 107, wherein said at least one minor phase component comprises a non-polymeric viscous material.

124. The method as recited in claim 107, wherein the chaotically mixing step is carried out as substantially two dimensional chaotic mixing.

125. The method as recited in claim 107, wherein the chaotically mixing step is carried out as substantially three dimensional chaotic mixing.

126. The method as recited in claim 107, wherein the chaotically mixing step comprises a plurality of substantially discrete controllable mixing stages of differing functionality to produce predetermined staged morphology changes within the group consisting of said major phase component and said at least one minor phase component.

127. The method as recited in claim 126, wherein the controlling step includes selectively varying the shear rate in the chaotic mixer at different stages during the chaotically mixing step.

128. The method as recited in claim 126, wherein the controlling step includes utilizing a selective combination of two dimensional chaotic mixing and three dimensional chaotic mixing during the chaotically mixing step.

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129. The method as recited in claim 126, wherein the controlling step includes reversing the direction of mixing during the chaotically mixing step whereby structural morphology development is at least partially reversed.

130. The method as recited in claim 107, wherein the controllably forming step includes delivering said structured extrudate to a die for forming.

131. The method as recited in claim 107, wherein said at least one minor phase component comprises a substantially solid phase material which remains in a substantially unmelted state within said chaotic mixer and said major phase component comprises a polymeric material which is in a substantially liquid state within said chaotic mixer.

132. The method as recited in claim 107, wherein said major phase component comprises a substantially solid phase material which remains in a substantially unmelted state within said chaotic mixer and said at least one minor phase component comprises a polymeric material which is in a substantially liquid state within said chaotic mixer.

133. The method as recited in claim 107, wherein said multiple phase composite material includes two or more minor phase components.

134. The method as recited in claim 107, wherein said multiple phase composite material includes three or more polymeric constituents.

135. The method as recited in claim 107, wherein at least one of the group consisting of said major phase component and said at least one minor phase component includes an interfacial tension reducing additive.

136. The method as recited in claim 107, wherein said major phase component is electrically conductive and said at least one minor phase component is substantially electrically non-conductive.

137. The method as recited in claim 107, wherein said major phase component is substantially electrically non-conductive and said at least one minor phase component is electrically conductive.

138. The method as recited in claim 107, wherein the supplying steps and the discharging step are carried out in a substantially continuous manner.

139. The method as recited in claim 107, wherein during the controlling step, the physical properties of said in-situ structured extrudate are monitored to establish the extent of hole formation within said substantially discrete layers and the chaotically mixing step is adjusted to yield desired levels of hole formation.

140. A method for the manufacture of a multiple phase composite construction having a major phase component and at least one minor phase component wherein said major phase component and said at least one minor phase component are in interpenetrating blended relation with one another, the method comprising the steps of:

supplying said major phase component to a chaotic mixer in a substantially controlled manner;

supplying said at least one minor phase component to said chaotic mixer in a substantially controlled manner;

10       chaotically mixing said major phase component with said at least  
one minor phase component within said chaotic mixer such that said  
major phase component and said at least one minor phase component  
form an in-situ structured arrangement comprising an interpenetrating

blend of said major phase component and said at least one minor phase  
15 component;

controlling the chaotic mixing step such that the chaotic mixing is  
terminated at a controlled stage of interpenetration of said major phase  
and said at least one minor phase;

20 discharging said in-situ structured arrangement from said chaotic  
mixer in the form of a structured extrudate; and

controllably forming said in-situ structured extrudate into a  
substantially solid multiple phase construction wherein said major phase  
component and said at least one minor phase component are arranged  
in interpenetrating blended relation.

141. The method as recited in claim 140, wherein said major  
phase component comprises a polymeric material.

142. The method as recited in claim 141, wherein said major  
phase component is in a substantially liquid state during the chaotically  
mixing step.

143. The method as recited in claim 140, wherein said at least  
one minor phase component comprises a polymeric material.

144. The method as recited in claim 143, wherein said at least  
one minor phase component is in a substantially liquid state during the  
chaotic mixing step.

145. The method as recited in claim 140, wherein at least one  
of the group consisting of said major phase component and said at least  
one minor phase component comprises a substantially solid phase  
material which remains substantially unmelted during said chaotically  
5 mixing step.

146. The method as recited in claim 145, wherein said substantially solid phase material is electrically conductive.

147. The method as recited in claim 140, wherein said major phase component comprises a non-polymeric viscous material.

148. The method as recited in claim 140, wherein said at least one minor phase component comprises a non-polymeric viscous material.

149. The method as recited in claim 140, wherein the chaotic mixing step is carried out as substantially two dimensional chaotic mixing.

150. The method as recited in claim 140, wherein the chaotic mixing step is carried out as substantially three dimensional chaotic mixing.

151. The method as recited in claim 140, wherein the chaotically mixing step comprises a plurality of substantially discrete controllable mixing stages of differing functionality to produce predetermined staged morphology changes within the group consisting  
5 of said major phase component and said at least one minor phase component.

152. The method as recited in claim 151, wherein the controlling step includes selectively varying the shear rate in the chaotic mixer at different stages during the chaotically mixing step.

153. The method as recited in claim 151, wherein the controlling step includes utilizing a selective combination of two

dimensional chaotic mixing and three dimensional chaotic mixing during the chaotically mixing step.

154. The method as recited in claim 151, wherein the controlling step includes reversing the direction of mixing during the chaotically mixing step whereby structural morphology development is at least partially reversed such that interpenetrating between said major 5 phase component and said at least one minor phase component is reduced.

155. The method as recited in claim 140, wherein said supplying steps and said discharging steps are carried out in a substantially continuous manner.

156. The method as recited in claim 140, wherein at least one of the group consisting of said major phase component and said at least one minor phase component includes an additive to reduce interfacial tension.

157. The method as recited in claim 140, wherein said major phase component is substantially electrically conductive and said at least one minor phase component is electrically nonconductive.

158. The method as recited in claim 140, wherein said major phase component is substantially electrically nonconductive and said at least one minor phase component is electrically conductive.

159. The method as recited in claim 158, wherein said major phase component is a plastic and said at least one minor phase component is an electrically conductive additive.

160. The method as recited in claim 159, wherein electrical resistivity of said multiple phase construction initially decreases to a predefined limit during the chaotically mixing step as said major phase component and said at least one minor phase component undergo 5 interpenetration, and wherein electrical resistivity thereafter undergoes a subsequent rapid increase so as to approach a substantially insulating character upon further chaotic mixing and wherein during the controlling step the chaotically mixing step is terminated at a stage resulting in a desired level of electrical resistivity.

161. The method as recited in claim 160, wherein the chaotic mixer is reversed in response to a measured increase in the resistivity of the interpenetrating blend at an advanced stage of chaotic mixing whereby a controlled decrease in electrical resistivity is realized within 5 said interpenetrating blend.

162. A method for the manufacture of a multiple phase composite construction having a first phase polymeric component and a second phase polymeric component wherein said first and second phase polymeric components are in interpenetrating blended relation 5 with one another, the method comprising the steps of:

supplying said first phase polymeric component to a chaotic mixer in a substantially controlled manner;

supplying said second phase polymeric component to said chaotic mixer in a substantially controlled manner;

10 chaotically mixing said first phase polymeric component with said second phase polymeric component within said chaotic mixer to yield an in-situ structured arrangement comprising an interpenetrating blend of said major phase component and said minor phase component;

15 controlling the chaotic mixing step such that the chaotic mixing is terminated at a controlled stage of interpenetration of said first phase polymeric component and said second phase polymeric component;

discharging said in-situ structured arrangement from said chaotic mixer in the form of a structured extrudate; and

controllably forming said structured extrudate into a substantially solid multiple phase construction wherein said first phase polymeric component and said second phase polymeric component are disposed in interpenetrating blended relation wherein said first phase polymeric component and said second phase se polymeric are present at levels within said interpenetrating blend such that;

25

$$\frac{V_a}{V_b} \frac{\mu_b}{\mu_a}$$

may not substantially equal 1 wherein,

30

$V_a$  is the volume percentage of said first phase polymeric component;

$V_b$  is the volume percentage of said second phase polymeric component;

35

$\mu_a$  is the viscosity of said first phase polymeric component during the chaotically mixing step; and

$\mu_b$  is the viscosity of said second phase polymeric component during the chaotically mixing step.

163. The method as recited in claim 162, wherein:

$$\frac{V_a}{V_b} \frac{\mu_b}{\mu_a}$$

5

is greater than about 2.

164. The method as recited in claim 162, wherein:

$$\frac{V_a}{V_b} \frac{\mu_b}{\mu_a}$$

5

is greater than about 5.

165. The method as recited in claim 162, wherein:

$$\frac{V_a \mu_b}{V_b \mu_a}$$

5

is in the range of about 10 to about 140.

166. The method as recited in claim 162, wherein said first phase polymeric component is low density polyethylene and said second phase polymeric component is polystyrene.

167. A method for the manufacture of a multiple phase composite construction having a major phase component and at least one minor phase component arranged in a desired predefined morphological structure comprising a plurality of substantially discrete platelets, the method comprising the steps of:

supplying said major phase component to a chaotic mixer in a substantially controlled manner;

supplying said at least one minor phase component to said chaotic mixer in a substantially controlled manner;

chaotically mixing said major phase component with said at least one minor phase component within said chaotic mixer such that said major phase component and said at least one minor phase component form an in-situ structured arrangement formed progressively according to a preestablished and controllable evolutionary process, wherein said structured arrangement comprises a plurality of substantially discrete platelets of said major phase component and said at least one minor phase component;

controlling the chaotically mixing step such that the chaotic mixing is terminated at a controlled stage following formation of said substantially discrete platelets;

20 discharging said in-situ structured arrangement from said chaotic mixer in the form of a structured extrudate; and

controllably forming said structured extrudate into a substantially solid structure having said predefined morphological structure.

168. The method as recited in claim 167, wherein said major phase component comprises a polymeric material.

169. The method as recited in claim 168, wherein said at least one minor phase component comprises a polymeric material.

170. The method as recited in claim 167, wherein said major phase component comprises a non-polymeric viscous material.

171. The method as recited in claim 167, wherein said at least one minor phase component comprises a non-polymeric viscous material.

172. The method as recited in claim 167, wherein the chaotic mixing step is carried out as substantially two dimensional chaotic mixing.

173. The method as recited in claim 167, wherein the chaotic mixing step is carried out as substantially three dimensional chaotic mixing.

174. The method as recited in claim 167, wherein the chaotically mixing step comprises a plurality of substantially discrete controllable mixing stages of differing functionality to produce

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predetermined staged morphology changes within the group consisting  
5 of said major phase component and said at least one minor phase  
component.

175. The method as recited in claim 174, wherein the  
controlling step includes selectively varying the shear rate in the chaotic  
mixer at different stages during the chaotically mixing step.

176. The method as recited in claim 174, wherein the  
controlling step includes utilizing a selective combination of two  
dimensional chaotic mixing and three dimensional chaotic mixing.

177. The method as recited in claim 174, wherein the  
controlling step includes reversing the direction of mixing during the  
chaotically mixing step whereby structural morphology development is at  
least partially reversed such that the size of the platelets within the in-  
5 situ structured arrangement is increased.

178. The method as recited in claim 174, wherein said  
supplying steps and said discharging steps are carried out in a  
substantially continuous manner.

179. The method as recited in claim 167, wherein said multiple  
phase composite construction includes two or more minor phase  
components.

180. The method as recited in claim 167, wherein said multiple  
phase composite construction includes three or more polymeric  
constituents.

181. The method as recited in claim 167, wherein at least one  
of the group consisting of said major phase component and said at least

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one minor phase component includes an additive to reduce interfacial tension.

182. The method as recited in claim 167, wherein said major phase component is electrically conductive and said at least one minor phase component is substantially electrically non-conductive.

183. The method as recited in claim 167, wherein said major phase component is substantially electrically non-conductive and said at least one minor phase component is electrically conductive.

184. A method for the manufacture of a fibrous construction having a major phase component and at least one minor phase component arranged in a desired predefined morphological structure comprising a plurality of fiber elements, the method comprising the steps  
5 of:

supplying said major phase component to a chaotic mixer in a substantially controlled manner;

supplying said at least one minor phase component to said chaotic mixer in a substantially controlled manner;

10 chaotically mixing said major phase component with said at least one minor phase component within said chaotic mixer such that said major phase component and said at least one minor phase component assume an in-situ structured arrangement comprising a plurality of elongate fiber-like phase structures of said major phase component and  
15 said at least one minor phase component;

controlling the chaotic mixing step such that the chaotic mixing is terminated at a controlled stage following formation of said elongate fiber-like phase structures; and

20 discharging said structured arrangement from said chaotic mixer in the form of a structured extrudate including said elongate fiber-like phase structures.

185. A fibrous construction formed according to the method as recited in claim 184, wherein said fiber elements have an average diameter in the range of not greater than about 200 nanometers.

186. A fibrous construction formed according to the method as recited in claim 184, wherein said fiber elements have an average diameter in the range of not greater than about 100 nanometers.

187. A fibrous construction formed according to the method as recited in claim 184, wherein said fiber elements have an average diameter in the range of not greater than about 50 nanometers.

188. The method as recited in claim 184 wherein said major phase component and said at least one minor phase component are miscible.

189. The method as recited in claim 184 wherein said major phase component and said at least one minor phase component are immiscible.

190. The method as recited in claim 184, wherein said major phase component comprises a polymeric material.

191. The method as recited in claim 190, wherein said at least one minor phase component comprises a polymeric material.

192. The method as recited in claim 184, wherein the controlling step includes utilizing a selective combination of two dimensional chaotic mixing and three dimensional chaotic mixing during the chaotically mixing step.

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193. The method as recited in claim 184, wherein the controlling step includes reversing the direction of mixing during the chaotically mixing step.

194. The method as recited in claim 184, wherein the supplying steps and the discharging step are carried out in a substantially continuous manner.

195. The method as recited in claim 184, wherein at least one of the group consisting of said major phase component and said at least one minor phase component includes an additive to reduce interfacial tension.

196. The method as recited in claim 184, wherein said major phase component is electrically conductive and said at least one minor phase component is substantially electrically non-conductive.

197. The method as recited in claim 184, wherein said major phase component is substantially electrically non-conductive and said at least one minor phase component is electrically conductive.

198. A method for the manufacture of a multi-phase construction having a major phase component and at least one minor phase component arranged in a desired predefined morphological structure wherein at least one of the group consisting of said major phase component and said at least one minor phase components is present in the form of a plurality of disperse droplets, the method comprising the steps of:

- 5           supplying said major phase component to a chaotic mixer in a substantially controlled manner;
- 10          supplying said at least one minor phase component to said chaotic mixer in a substantially controlled manner;

chaotically mixing said major phase component with said at least one minor phase component within said chaotic mixer such that said major phase component and said at least one minor phase component  
15 assume an in-situ structured arrangement comprising a plurality of disperse droplets of said at least one minor phase component;  
controlling the chaotic mixing step such that the chaotic mixing is terminated at a controlled stage following formation of said disperse droplets;  
20 discharging said in-situ structured arrangement from said chaotic mixer in the form of a structured extrudate including a plurality of disperse droplets of said at least one minor phase component; and controllably forming said structured extrudate into a substantially solid multiple phase construction.

199. The method as recited in claim 198, wherein said disperse droplets have an average diameter of not greater than about 200 nanometers.

200. The method as recited in claim 198, wherein said disperse droplets have an average diameter of not greater than about 100 nanometers.

201. The method as recited in claim 198, wherein said disperse droplets have an average diameter of not greater than about 50 nanometers.

202. The method as recited in claim 198 wherein at least one of the group consisting of said major phase component and said at least one minor phase component is a rubber.

203. A method for the production of a multiple phase composite material, wherein the composite material comprises a major phase

component and at least one minor phase component arranged in a desired predefined morphological structure in which said major phase component and said at least one minor phase component have predefined substantially controllable size and shape characteristics, the method comprising the steps of:

supplying said major phase component to a chaotic mixer in a substantially controlled manner;

10 supplying said at least one minor phase component to said chaotic mixer in a substantially controlled manner;

chaotically mixing said major phase component with said at least one minor phase component within said chaotic mixer while the supplying steps are ongoing such that said major phase component and said at least one minor phase component assume phase structures of substantially extended dimension developed substantially progressively within said chaotic mixer according to a pre-established controllable evolutionary process, wherein said phase structures have morphologies selected from the group consisting of multi-layered films having a

15 substantially extensive length dimension, multi-layered films having a substantially extensive length dimension wherein at least a portion of the layers include holes of controllable size, platelets of substantially extensive length dimension, fibers of substantially extensive length dimension and combinations thereof;

20 controlling the chaotically mixing step and the supplying steps to yield predefined size and shape characteristics of said phase structures;

25 discharging said major phase component and said at least one minor phase component from said chaotic mixer in the form of a structured extrudate wherein said phase structures are present in a substantially uniform repeating arrangement extending substantially throughout said structured extrudate; and

30 controllably forming said structured extrudate into a substantially solid construction having said predefined morphological structure.

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204. A multilayer structure comprising a plurality of extended film layers of a major phase component and at least one minor phase component wherein at least a portion of said film layers have a thickness in the range of not greater than about 200 nanometers.

205. The multilayer structure according to claim 204, wherein at least a portion of said film layers are substantially continuous.

206. The multilayer structure according to claim 204, wherein at least a portion of said film layers are discontinuous including holes extending between contiguous layers.

5 207. The multilayer structure according to claim 204, wherein at least a portion of said film layers are electrically conductive and wherein at least a portion of said film layers are electrically nonconductive and wherein said nonconductive layers are disposed between said conductive layers such that the multilayer structure is electrically conductive in a direction extending substantially parallel to said layers and is nonconductive in a direction extending substantially transverse to said layers.

208. The multilayer structure according to claim 204, comprising greater than about 6 layers.

209. The multilayer structure according to claim 204, comprising not less than about 10 layers.

210. The multilayer structure according to claim 204, comprising about 10 to about 100 layers.

211. The multilayer structure according to claim 204, comprising about 100 to about 12,000 layers.

212. The multilayer structure according to claim 204, wherein said film layers have a thickness in the range of not greater than about 100 nanometers.

213. The multilayer structure according to claim 212, wherein at least a portion of said film layers are substantially continuous.

214. The multilayer structure according to claim 212, wherein at least a portion of said film layers are discontinuous including holes extending between contiguous layers.

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215. The multilayer structure according to claim 212, wherein at least a portion of said film layers are electrically conductive and wherein at least a portion of said film layers are electrically nonconductive and wherein said nonconductive layers are disposed between said conductive layers such that the multilayer structure is electrically conductive in a direction extending substantially parallel to said layers and is nonconductive in a direction extending substantially transverse to said layers.

216. The multilayer structure according to claim 212, comprising greater than about 6 layers.

217. The multilayer structure according to claim 212, comprising not less than about 10 layers.

218. The multilayer structure according to claim 212, comprising about 10 to about 100 layers.

219. The multilayer structure according to claim 212, comprising about 100 to about 12,000 layers.

220. The multilayer structure according to claim 204, wherein said film layers have a thickness in the range of not greater than about 50 nanometers.

221. The multilayer structure according to claim 220, wherein at least a portion of said film layers are substantially continuous.

222. The multilayer structure according to claim 220, wherein at least a portion of said film layers are discontinuous including holes extending between contiguous layers.

5

223. The multilayer structure according to claim 220, wherein at least a portion of said film layers are electrically conductive and wherein at least a portion of said film layers are electrically nonconductive and wherein said nonconductive layers are disposed between said conductive layers such that the multilayer structure is electrically conductive in a direction extending substantially parallel to said layers and is nonconductive in a direction extending substantially transverse to said layers.

224. The multilayer structure according to claim 220, comprising greater than about 6 layers.

225. The multilayer structure according to claim 220, comprising not less than about 10 layers.

226. The multilayer structure according to claim 220, comprising about 10 to about 100 layers.

227. The multilayer structure according to claim 220, comprising about 100 to about 12,000 layers.

228. A multiple phase polymeric composite comprising a first phase polymeric constituent and a second phase polymeric constituent disposed in interpenetrating blended relation with one another such that the first phase polymeric constituent and the second phase polymeric constituent are substantially continuous throughout the composite and wherein;

$$\frac{V_a}{V_b} \frac{\mu_b}{\mu_a}$$

10 may not substantially equal 1 where,

$V_a$  is the volume percentage of said first phase polymeric constituent;

15  $V_b$  is the volume percentage of said second phase polymeric constituent;

$\mu_a$  is the viscosity of said first phase polymeric constituent; and  
 $\mu_b$  is the viscosity of said second phase polymeric constituent.

229. The multiple phase polymeric composite according to claim 228 wherein:

$$5 \quad \frac{V_a}{V_b} \frac{\mu_b}{\mu_a}$$

is greater than about 2.

230. The multiple phase polymeric composite according to claim 228 wherein:

$$5 \quad \frac{V_a}{V_b} \frac{\mu_b}{\mu_a}$$

is greater than about 5.

231. The multiple phase polymeric composite according to claim 228 wherein:

5

$$\frac{V_a}{V_b} \frac{\mu_b}{\mu_a}$$

is in the range of about 10 to about 140.

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